

The safe gate to the posterior paranasal sinuses: reassessing the role of the superior turbinate

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Abstract Surgery of the posterior ethmoid and sphenoid sinuses can be challenging. In 1999, a technique was described for identification of the superior turbinate and utilizing it as a landmark in endoscopic posterior ethmoidectomy and sphenoidotomy. Although this was more than a decade ago, it has not been supported by further studies. In our practice, we have routinely adopted this technique, and have modified it to allow further orientation during endoscopic surgery of the posterior sinuses. To describe a review of our technique, and to prospectively assess the value of the superior turbinate as a useful landmark during endoscopic posterior ethmoidectomy and sphenoidotomy. Fifty patients listed for endoscopic posterior ethmoidectomy with or without sphenoidotomy were included in a prospective study utilising our surgical technique. Data were collated for the success or failure of identification of the landmarks, and for any complications during the surgery. A total of 93 sides of endoscopic posterior ethmoidectomy and 73 sides of endoscopic sphenoidotomy were performed. The superior turbinate was identified in 100% of the cases. The coronal part of the superior turbinate basal lamella was identified in 60.22% of the cases, and the axial part in 88.17% of the cases. The natural sphenoid ostium

was identified medial to the posterior part of the superior turbinate in 98.63% of the cases. The axial part of the superior turbinate basal lamella was a constant landmark for the level of the sphenoid ostium. The number of transverse septae between the axial part of the superior turbinate basal lamella and the skull base was studied, and was found never to exceed one septum. No major complications were recorded. One case of small posterior septal perforation was detected with no post-operative effects. Our study represents the first report of identifying the two parts of the superior turbinate basal lamella intra-operatively. It also represents the first report of using the axial basal lamella of the superior turbinate as a landmark for the level of the sphenoid sinus ostium, as well as a landmark for the level of the skull base. The superior turbinate represents a constant landmark for performing a safe posterior ethmoidectomy and sphenoidotomy.

Keywords Superior turbinate · Basal lamella · Posterior ethmoid · Sphenoidotomy · Endoscopic sinus surgery

Introduction

Functional endoscopic sinus surgery (FESS) is now a well-established technique for treatment of rhinosinusitis not responding to medical treatment [1]. Endoscopic surgery of the posterior ethmoid and sphenoid sinuses can be particularly challenging. A reliable landmark that aids surgical orientation within this area can be very useful in avoiding serious complications [2].

The posterior ethmoids are known to drain into the superior meatus, lateral to the superior turbinate. The sphenoid sinus drains into the sphenoidal recess, medial to the superior turbinate [3].

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In 1999, a group of eminent rhinologists from a number of American centres published two articles to describe a technique for identification of the superior turbinate and utilizing it as a landmark in endoscopic posterior ethmoidectomy and sphenoidotomy [2, 4] Although this was more than a decade ago, there have not been, to the best of our knowledge, any further articles confirming or contradicting the operative experience of the above group. There have been, however, several articles presenting cadaveric and/or radiological studies of the superior turbinate [5–9].

The authors of the current article have routinely used the technique published in 1999 [2, 4] for identification of the superior turbinate, and relying upon it as a landmark during endoscopic surgery involving the posterior ethmoid and sphenoid sinuses. In addition, we have further modified the technique by attempting to identify the two parts of the basal lamella of the superior turbinate. These structures are then used for further orientation during endoscopic posterior ethmoidectomy and sphenoidotomy. The aim of this article is to describe a prospective evaluation of our technique, and to assess the value of the superior turbinate as a useful landmark during endoscopic surgery of the posterior sinuses.

Patients and methods

The study was a prospective case cohort. The inclusion in the study was for all patients listed for endoscopic sinus surgery (ESS), for whom posterior ethmoidectomy was required. Fifty patients were included. Data were collated for the success or failure of identification of the landmarks, and for any complications during the surgery. No ethics approval was required as the authors did not shift from their routine technique of ESS during the study.

Surgical technique

An anterior ethmoidectomy was performed as described by Kennedy [10]. The coronally oriented part of the basal lamella of the middle turbinate was identified, and was opened in its medial part at the level of the roof of the maxillary sinus to gain entry to the posterior ethmoids. Entry at this level of the basal lamella allowed rapid identification of the anteroinferior part of the superior turbinate as described in 1999 [4]. In the rare cases where the maxillary sinus was hypoplastic, or decision was made not to do an anrostomy for other reasons, we then identified the posterior axially oriented part of the basal lamella of the middle turbinate and followed it from behind forwards until it came to the point where it turned vertically to become coronally oriented. The basal lamella was opened at this point in its medial part. This technique as well allowed entry to the posterior ethmoids at a point which aided identification of

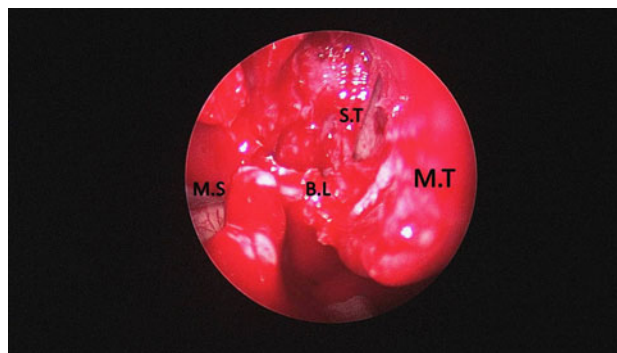


Fig. 1 Identification of superior turbinate. A view during right endoscopic ethmoidectomy showing the basal lamella of the middle turbinate opened with its inferior part preserved. The superior turbinate is seen through the basal lamella (*M.T* middle turbinate, *B.L* basal lamella of middle turbinate, *S.T* superior turbinate, *M.S* maxillary sinus)

the anteroinferior part of the superior turbinate. This was followed by removal of further parts of the basal lamella of the middle turbinate to allow better entry to the posterior ethmoids, and full identification of the superior turbinate (Fig. 1). The inferior part of the basal lamella was not removed to avoid destabilisation of the middle turbinate.

Attention was then focused on the superior turbinate and the posterior ethmoids. The posterior ethmoidal cells lateral to the inferior half of the superior turbinate were dissected, leaving the cells closer to the skull base until later when the skull base had been identified. The lamina papyracea was then identified as the lateral limit of the dissection, and attention was turned again to the superior turbinate. Our observations showed that the superior turbinate had a basal lamella formed of two identifiable parts. Similar to the middle turbinate basal lamella, these are an anterior coronally oriented part, and a posterior axially oriented part. This observation had been previously reported in cadaveric and radiological studies [5], but had not been commented upon in actual operative studies. Both the coronal and axial parts were attached laterally to the lamina papyracea. The coronal part was attached superiorly to the skull base. The axial part was attached posteriorly to the anterior face of sphenoid. If the coronal part was identified, this was opened in its inferomedial part to expose the face of sphenoid behind it (Fig. 2). The coronal part was then gradually removed leaving its uppermost part which was attached to the skull base, and its most lateral which was attached to the lamina papyracea. These parts were preserved to maintain orientation of the position of the superior turbinate basal lamella until the end of the procedure when they could then be removed. If the coronal part was not present, the previous step was omitted. The axial part was then identified and followed posteriorly to its attachment to the face of sphenoid to positively identify the latter structure. The skull base was then positively identified above the face of sphenoid, and

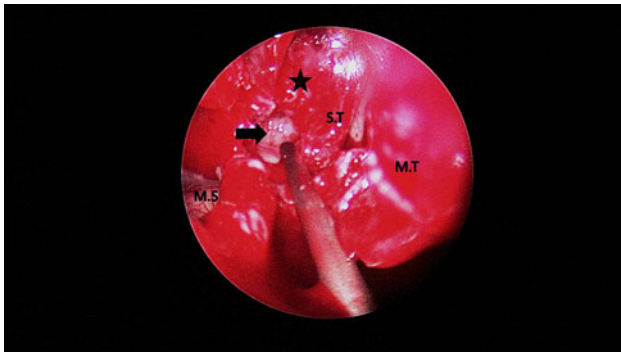


Fig. 2 Opening the basal lamella of the superior turbinate. A view during right endoscopic ethmoidectomy showing a suction tip introduced through an opening made in the coronal part of the superior turbinate basal lamella. The opening (marked by the arrow) is first made in the inferomedial part and then progressively widened to include most of the remaining coronal basal lamella (marked by the star) (M.T middle turbinate, S.T superior turbinate, M.S maxillary sinus)

the space between it and the axial basal lamella was inspected for transverse septae. In our experience, we never identified more than one transverse septum attached to the face of sphenoid between the axial basal lamella of the superior turbinate and the skull base (Fig. 3). In many cases, no transverse septae attached to the face of sphenoid were identified between these 2 structures (Fig. 4). After detecting the above anatomical landmarks, a parallelogram was identified as described by Bolger et al. [2], formed of the superior turbinate medially, the lamina papyracea laterally, the skull base superiorly and the axial part of the superior turbinate basal lamella inferiorly. Additionally, we further identified the presence of coronal and axial planes within this parallelogram dividing it into smaller parallelograms. The coronal internal plane was formed by the coronal part of the basal lamella of the superior turbinate, while the axial internal plane was formed by the transverse septae attached to the face of sphenoid between the axial part of the basal lamella of the superior turbinate and the skull base (Fig. 3). Identification of these additional planes allowed precise orientation within the posterior ethmoids, and helped to avoid any complications within this difficult area. After full identification of all landmarks, any remaining cells or septae were then removed.

If a sphenoidotomy was required, the natural ostium of the sphenoid was always identified first and then dilated. This was done by palpating the face of the sphenoid medial to the superior turbinate at the level of the superior turbinate axial basal lamella. The medial side of the superior turbinate was accessed via the trans-ethmoidal route rather than the trans-nasal route to avoid lateralisation and destabilisation of the middle turbinate. Resection of the inferior third of the superior turbinate was usually required to reach the sphenoid ostium. We always performed this resection using sharp cutting instruments or a microdebrider to avoid

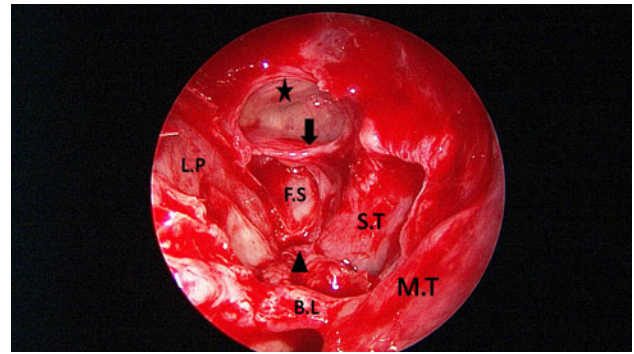


Fig. 3 Anatomical landmarks in the posterior ethmoids. A view during right endoscopic ethmoidectomy showing an anatomical parallelogram in the posterior ethmoids, with the superior turbinate (S.T) forming its medial wall, the lamina papyracea (L.P) forming its lateral wall, the skull base (star) forming its roof and the axial part of the superior turbinate basal lamella (arrowhead) forming its floor. The coronal part of the superior turbinate basal lamella has been opened to expose the anterior face of sphenoid (F.S). One transverse septum (arrow) is attached to the face of sphenoid between the axial basal lamella and the skull base, dividing the parallelogram into an upper and lower smaller parallelograms (M.T middle turbinate, B.L basal lamella of the middle turbinate, S.T superior turbinate, L.P lamina papyracea, F.S anterior face of sphenoid)

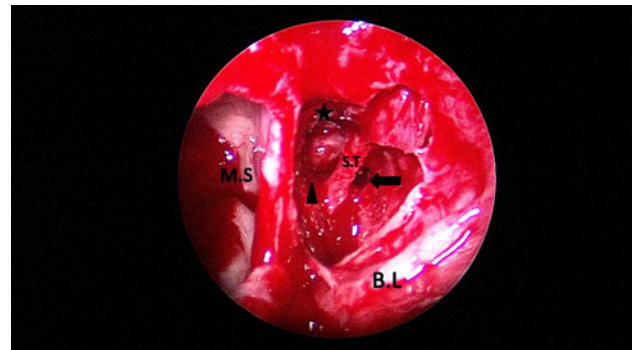


Fig. 4 The superior turbinate as a landmark during posterior ethmoidectomy and sphenoidotomy. A view during right endoscopic sphenoidectomy showing the skull base (star) above the axial part of the superior turbinate basal lamella (arrowhead), with no transverse septae in between. The sphenoid natural ostium (arrow) is identified medial to the superior turbinate at almost the same level of the axial superior turbinate basal lamella (B.L basal lamella of the middle turbinate, S.T superior turbinate, M.S maxillary sinus)

traction on the superior turbinate. In our experience, the natural ostium of the sphenoid sinus could almost always be identified medial to the superior turbinate, very close to the level of its axial basal lamella (Fig. 5).

Results

The study was conducted on 50 patients, including 33 males and 17 females. The age ranged from 18 to 80 years, with a mean age of 50.76 (± 16.25). All patients had endoscopic posterior ethmoidectomy. This was done bilaterally

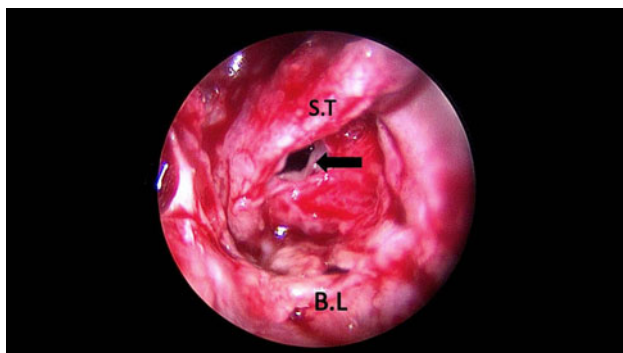


Fig. 5 Endoscopic sphenoidotomy. An endoscopic view of the right natural sphenoid ostium (*arrow*) showing its position medial to the posterior end of the superior turbinate (*S.T*) (*B.L* basal lamella of middle turbinate, *S.T* superior turbinate)

in 43 patients, and unilaterally in 7 patients, resulting in a total of 93 sides of endoscopic posterior ethmoidectomy. Endoscopic sphenoidotomy was performed in 73 sides (Fig. 5).

The indication for surgery was inflammatory disease not responding to medical treatment in all 50 patients. The pathology was non polypoid chronic rhinosinusitis in 19 patients, chronic rhinosinusitis with middle meatal polyposis in 2 patients, unilateral nasal polyps in 1 patient and diffuse sinonasal polyps in 28 patients.

In 36 patients, the surgery was a primary one. In 14 patients, the surgery was a revision. In the latter group, the number of previous procedures ranged from 1 to 6 per patient.

The superior turbinate was positively identified in all 93 operated sides (100%). In one patient who previously had 6 surgical procedures and still presented with aggressive diffuse sinonasal polyps, the middle turbinate was completely absent in the left side. Identification of the superior turbinate was difficult due to the absence of landmarks. The sphenoid ostium was identified trans-nasally using its relation to the choana, and the superior turbinate was identified lateral to it. The superior turbinate was then used as a landmark to perform the posterior ethmoidectomy as explained above.

The coronal part of the basal lamella of the superior turbinate was positively identified in 56 sides (60.22%), including 27 out of 46 right sided posterior ethmoidectomy procedures (58.7%), and 29 out of 47 left sided posterior ethmoidectomy procedures (61.7%).

The axial part of the basal lamella of the superior turbinate was positively identified in 82 sides (88.17%), including 40 out of 46 right sided posterior ethmoidectomy procedures (86.96%), and 42 out of 47 left sided posterior ethmoidectomy procedures (89.36%).

The presence of transverse ethmoidal septae attached to the face of sphenoid between the axial part of the superior turbinate basal lamella and the skull base was studied in 75

operated sides. In 40 sides (53.33%), no transverse septae were found. In 35 sides (46.67%), 1 transverse septum was found. We have not detected any case with more than one transverse septum attached to the face of sphenoid between the axial basal lamella of the superior turbinate and the skull base.

Out of 73 sides of attempted endoscopic sphenoidotomy, the natural ostium was identified in 72 cases (98.63%). In the remaining case, the sinus was seen on the preoperative scan to have limited pneumatisation, with large sphenoidal “Onodi” cells pneumatising into its superolateral wall. The Onodi cells were of almost similar size to the sphenoid sinus, and it was thus difficult intraoperatively to be sure that the sphenoid was entered. All 72 identified natural sphenoid ostia were located medial to the posterior part of the superior turbinate. The vertical position of the natural sphenoid ostium was always very close to the level of the axial part of the basal lamella of the superior turbinate. In 21 sides (29.17%), it was almost at the same level as the axial basal lamella. In 25 sides (34.72%), it was just above the level of the axial basal lamella. In 26 sides (36.11%), it was just below the level of the axial basal lamella.

No major complications were detected during any of the procedures. Only one minor complication was detected in the form of a small posterior septal perforation that occurred while searching for the sphenoid ostium. As this was a very posterior perforation, it did not cause any symptoms postoperatively.

Discussion

In 1999, Bolger et al. [2] described a technique for posterior ethmoidectomy where an anatomical parallelogram is identified, with the superior turbinate forming 2 of the 4 sides of this parallelogram. They stressed in their article on the importance of the superior turbinate as a landmark during posterior ethmoidectomy and sphenoidotomy. Later in the same year, a group led by Kennedy, and including two of the senior authors of the above article, published another article stressing again on the role of the superior turbinate in ESS [4]. For more than a decade following these two publications, there have been no reports confirming or rejecting the conclusions presented in them. We have routinely adopted the technique published in these two articles, and our results have confirmed that the superior turbinate and at least 3 sides of the anatomical parallelogram in the posterior ethmoids could be identified in 100% of the cases. The fourth side could also be identified in 88% of the cases. The superior turbinate could be identified even in revision surgery for diffuse polypoid pathology following multiple previous procedures, and even in the absence of traditional landmarks like the middle turbinate.

Identification of the two parts of the basal lamella of the superior turbinate represented an additional landmark and provided further orientation within the posterior ethmoids. The coronal part of the superior turbinate basal lamella is attached superiorly to the skull base and laterally to the lamina papyracea, and thus can be used to identify these two vital structures. Once the coronal part is opened, another vital anatomical landmark, the anterior face of sphenoid, can be identified. If the coronal part is absent, which was the case in around 40% of our cases, the more constantly present axial part of the superior turbinate basal lamella can be used to identify the above structures. The axial part is attached posteriorly to the face of sphenoid and laterally to the lamina papyracea. The skull base lies above it, and is separated from it at the level of the face of sphenoid by a maximum of one transverse septum, according to our experience. When the coronal part of the superior turbinate basal lamella, and/or a transverse septum above the axial part of the basal lamella were identified, they represented additional planes within the posterior ethmoidal anatomical parallelogram, dividing it into smaller parallelograms, and allowing precise orientation within the area of the posterior ethmoids.

In our experience, the coronal part of the superior turbinate basal lamella could be identified only in 60% of the operated sides. In a detailed cadaveric and radiological study, Kim et al. [5] found that the coronal part of the superior turbinate basal lamella was only present in 69% of the specimens. In the remaining specimens, the axial part of the superior turbinate basal lamella fused with the middle turbinate basal lamella and inserted to the skull base as one structure. These anatomical findings are in accordance with our operative observations about the absence of the coronal superior turbinate basal lamella in 40% of the cases.

Kim et al. [5] identified the axial part of the superior turbinate basal lamella in 100% of their specimens. In our operative study, this structure was identified only in 88% of the operated sides. This discrepancy can be attributed to the degree of pathology encountered during the surgery, especially in revision cases, which might have affected our ability to identify this structure in some cases.

In our study, the superior turbinate has also proved to be a constant landmark for the natural ostium of the sphenoid sinus. Kim et al. [6] reported finding the sphenoid ostium medial to the superior turbinate in 83% of their cadaveric specimens, and lateral to it in the remaining 17%. Millar and Orlandi [9] found the sphenoid ostium medial to the superior turbinate in 100% of their cadaveric dissections. In our operative study, the sphenoid ostium was identified medial to the superior turbinate in 72 out of 73 sphenoidotomy sides performed. In the remaining side, the sinus was hypoplastic and its ostium could not be located. Our observations showed that the axial part of the superior turbinate

basal lamella was an excellent landmark for the vertical position of the natural sphenoid ostium. The latter was always located either at the same level, or slightly above or below the superior turbinate axial basal lamella. To the best of our knowledge, this observation has not been previously reported.

Conclusions

The superior turbinate represents an excellent landmark for performing a safe posterior ethmoidectomy and sphenoidotomy. This landmark is a constant one, and can be identified even in patients who had multiple previous surgical procedures and in whom other landmarks may be missing.

Summary

- The superior turbinate was suggested as an important landmark during endoscopic posterior ethmoidectomy and sphenoidotomy. The authors who originally described the technique of identifying the superior turbinate during these procedures did not comment on their success rate of identifying this anatomical structure, particularly during revision cases and cases with difficult or altered anatomy. Their work has not been reproduced by other authors.
- This study confirms the value of the superior turbinate as a landmark during endoscopic surgery of the posterior sinuses. It proves that it can be identified in 100% of the cases including difficult multiple revision ones, and even in the absence of the middle turbinate.
- This study is the first report of identifying an axial and a coronal part of the basal lamella of the superior turbinate intra-operatively. The two identified parts were utilised to allow precise orientation within the posterior ethmoids.
- This study confirms that the sphenoid sinus ostium can be identified medial to the superior turbinate in almost all cases. In some previous studies, it was suggested that the ostium could be lateral to the superior turbinate in a percentage of cases.
- This study is the first report showing the axial part of the superior turbinate basal lamella as a new landmark that can be reliably used to identify the level of the superior turbinate basal lamella.
- This study is the first report of the relation of the axial part of the superior turbinate basal lamella and the skull base. In our experience, a maximum of one transverse septum is present between these two structures. The axial basal lamella can thus be reliably used to identify the skull base.

Conflict of interest The authors declare no conflict of interest.

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